Research Note

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RELATIVE HUMIDITY AND FIRE BEHAVIOR IN LOGGING SLASH

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Relative humidity is one of the weather factors governing forest inflammability. Experimental burning of small plots of logging slash on the Priest River Experimental Forest in August 1952 afforded an opportunity to measure directly the effect of relative humidity on fire behavior as manifested by rate of spread. Plots containing different amounts of slash per acre were burned when relative humidity was increasing rapidly. Comparison of rate of spread with current relative humidity showed that high humidities greatly reduced rate of spread in light and medium slash concentrations but had no significant effect on fires in heavy concentrations.

RESEARCH METHODS[1/]

Thirty-six 0.01-acre plots of slash were burned during the period August 19-28, between the hours of 4:00 p.m. and 7:15 p.m. Twelve contained slash at the rate of 7.5 tons dry weight per acre, 12 at the rate of 20 tons per acre, and 12 at 32.5 tons per acre. Wind velocity was 0-2.4 miles per hour. Minimum moisture content of $\frac{1}{2}$-inch fuel sticks during the burning program was 6.3 percent; maximum was 9.7 percent.

Relative humidity was measured before each plot was burned and again at the end of the evening's operations. Relative humidity plotted over time of day gave a curve for the duration of each day's burning from which a relative humidity value was picked corresponding with the time midway between ignition and the conclusion of measurements on each plot. These mid-values were considered to be the average relative humidities which prevailed during the burning of the plots. Rate of radial spread was measured on four 10-foot diagonals extending from the plot center toward the corners.

1/ For complete description of the experiment see: Fahnestock, G. R. Inflammability of the current year's logging slash. Northern Rocky Mountain Forest and Range Experiment Station Research Note No. 124, August 1953.

RESULTS

Table 1 gives average relative humidity and average rate of radial spread for each plot by weight classes. Species is indicated for completeness only; it has been shown elsewhere that, for fresh slash, species is a factor only in light concentrations of species which lose their needles.[2/]

Significant correlation was found to exist between relative humidity and time per foot of radial spread on plots having 7.5 and 20 tons per acre of slash. Burning time was not significantly correlated with relative humidity on the 32.5-tons-per-acre plots, but it appeared possible that correlation would be demonstrable after collection of more data from subsequent burning.[3/]

In figure 1 the slope of the lines represents the effect of increasing relative humidity on burning time: the steeper the slope, the greater the retarding effect. The lines for 7.5- and 20-tons-per-acre slash plots have essentially the same slope, but both are very significantly steeper than the line for the 32.5-ton plots.[4/] Translated into more useful terms and generalized, figure 1 means that a rather rapid increase in humidity from 30 to 70 percent can be expected to reduce rate of spread[5/] 50-60 percent in slash concentrations of 7.5 to 20 tons per acre, but only about 25 percent in concentrations of 32.5 tons per acre.

DISCUSSIONS AND CONCLUSIONS

The humidity effect described here is one of increasing humidity. Therefore differences among weight classes express differences in rate of response to changing atmospheric conditions. The greatest range of humidity variation from start to finish of one day's burning was from 25 to 87 percent. During the same period the moisture content of 1/8-inch basswood slats increased 4.4 percent, while that of ½-inch sticks increased only 1.9 percent. Moisture content samples taken from the top layer of plots having 32.5 tons of slash per acre were found to contain more moisture than those taken from the lower portions of the same plots during periods when relative humidity was increasing rapidly.

2/ Op. cit.

3/ Correlation coefficients were as follows:
for 7.5-ton plots, .865 on 5 d.f.
for 20-ton plots, .873 on 10 d.f.
for 32.5-ton plots, .562 on 9 d.f.

4/ Equations for the three regression lines are:
for 7.5-ton plots, burning time = 1.06 (relative humidity) + 15.9
for 20-ton plots, burning time = .79 (relative humidity) — 3.7
for 32.5-ton plots, burning time = .15 (relative humidity) + 9.4

5/ Rate of perimeter increase, chains per hour.

Table 1. Average time per foot of spread and average relative humidity on each plot by weight classes

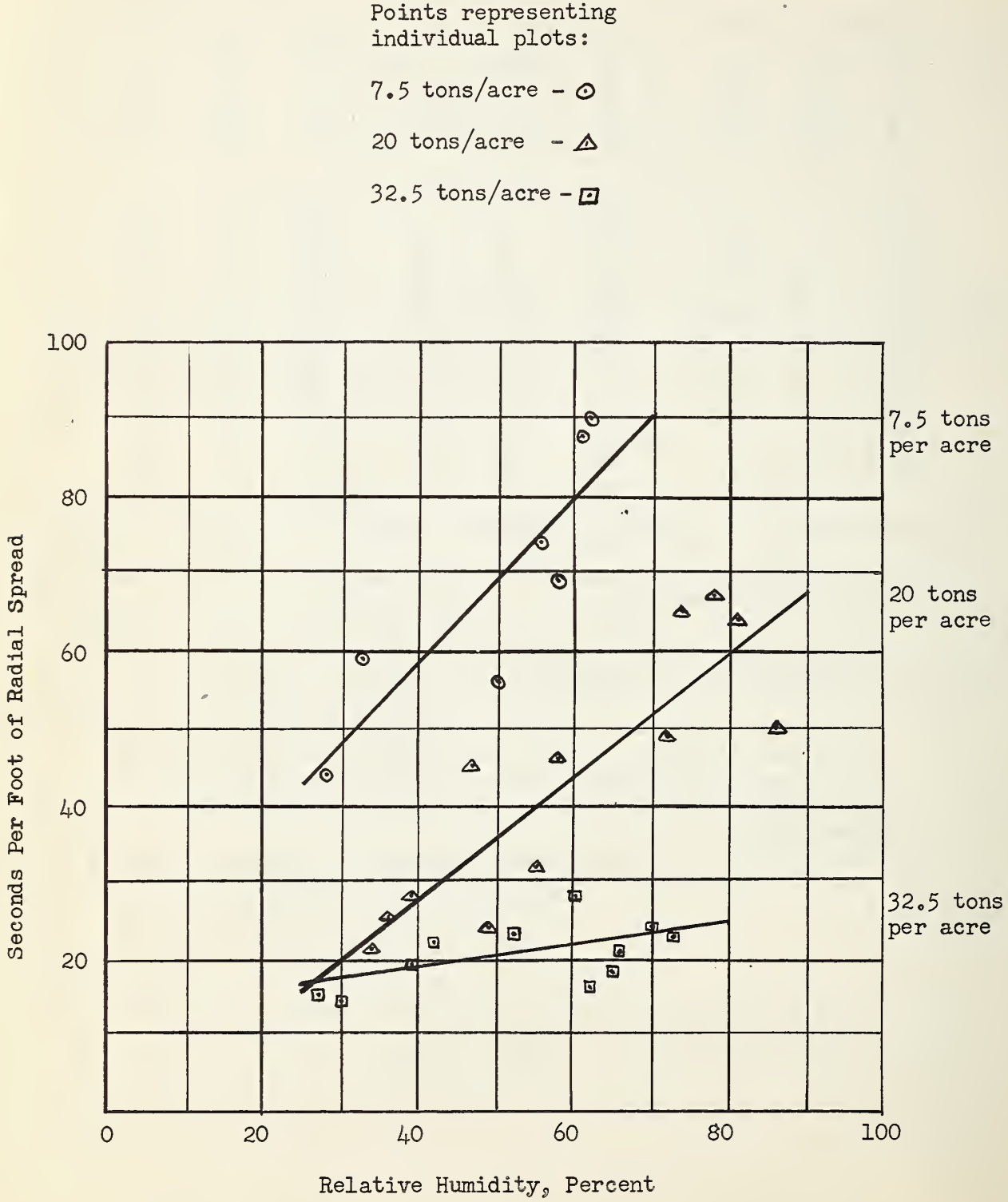
7.5 tons per acre			20 tons per acre			32.5 tons per acre		
Species[1]	Relative humidity	Rate sec./ft.	Species[1]	Relative humidity	Rate sec./ft.	Species[1]	Relative humidity	Rate sec./ft.
WRC	28	67	WWP	34	21	WH	27	15
DF	33	58	WRC	36	25	WWP	30	15
WH	36	2/	DF	39	28	WWP	39	20
DF	40	122 3/	WH	47	45	WRC	42	22
DF	50	56	WH	49	24	DF	52	23
WH	51	2/	WWP	55	33	WRC	60	28
WRC	51	120 3/	DF	58	46	DF	62	16
WRC	56	83	DF	72	49	WH	63	52 3/
WWP	58	68	WH	74	60	WWP	65	20
WWP	61	83	WRC	78	67	WH	66	21
WWP	62	92	WRC	81	66	DF	70	23
WH	67	2/	WWP	86	50	WRC	73	23

1/ WWP = western white pine; WRC = western redcedar; DF = Douglas-fir; WH = western hemlock.

2/ Light hemlock slash burned incompletely or not at all; therefore no time record was obtained.

3/ Observation before and during the burning of these three plots led to the conclusion that discontinuity of fuel would result in abnormally long burning times. Therefore, values for the three plots were not used in calculating correlations and regressions.

Figure 1. The relationship of rate of spread to relative humidity by slash weight classes.



In heavy concentrations of fine fuel, increases in relative humidity affect rate of spread more slowly than in light concentrations. Increasing the volume of fuel acts very much like increasing the size of fuel components. Two main factors account for slower response to increasing humidity in heavy concentrations: (1) a body of less exposed fuels is present which absorbs moisture relatively slowly, just as the interior of a log absorbs more slowly than the surface; and (2) the large amount of heat released dries out fuels in advance of the fire so rapidly as to overcome the effect of relatively small increases in moisture content. Collection of additional data from the burning of slash plots will permit more accurate evaluation of fuel volume as a factor modifying the effect of relative humidity on fire behavior.